

AN OPHTHALMO-DYNAMOMETER.

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The study of the ocular muscles, and of their influence in the production of certain ocular and nervous phenomena, has of late received no little attention from students of ophthalmology. As a result, I think it is now quite generally admitted, that these muscles may become a very important factor in the production of headache, of very distressing and persistent asthenopia and of a train of obscure, reflex nervous phenomena which often tax to the utmost the skill and patience of the surgeon under whose observation they may fall.

Whenever either from intrinsic lack of power or from insufficient innervation the ocular muscles are unable to maintain, without effort, their normal equilibrium, and binocular fixation of any point within the normal range of convergence is no longer easily possible, then very annoying symptoms, depending largely in intensity upon the nervous susceptibility of the patient, are almost sure to follow.

It oftentimes happens that this eye strain manifests itself in reflex phenomena, and no symptoms are present pointing to the eyes. These cases will apply for relief to their family physician, and upon his ability to recognize the true source of irritation depends his ability to relieve his patient. I trust, therefore, I shall be pardoned if I briefly allude to some simple tests for muscular insufficiency, and in describing the instrument which I have devised for measuring convergence and accommodation, if I enter more into detail than would be necessary in presenting the subject to men who have made this department of medicine a special study.

In some cases, muscular troubles are very easy of detection, in others they can only be demonstrated after repeated and most careful examinations; hence, one may feel sure that if he has discovered a lack of equilibrium by the tests at his command, he has found a very probable cause for the symptoms. But it must be remembered that it does not follow with equal certainty that when no lack of equilibrium is found muscular trouble does not exist.

One of the simplest tests for lack of equilibrium is to place before one eye, preferably the one with the greatest visual acuity, a red glass,



and direct the patient to look at the flame of a candle twenty feet distant. Should diplopia exist, you have muscular trouble of a considerable degree. Again, place before one eye a prism, say, of 5° , with its base either up or down, and again direct him to look at the candle. The two images should stand directly one over the other. When this is not the case, the one set of muscles overbalance the other, to an extent which is usually measured by the prism, that, placed with its base either to the nose or temple, will again bring the images in a line.

Again, with the eyes directed towards a candle flame, place a prism, 10° will usually suffice, with the base to the nose, the images will then be separated in the horizontal, and in like manner should keep the same plane.

The method of measuring the power of muscles most frequently employed, is, I think, the one by determining the strength of prism which the patient can overcome. For example, to determine the strength of the externi, prisms with their bases toward the nose are placed before the eye, and the strength of the prism increased till the strongest prism is determined through which the patient is able to see clearly, and overcome the tendency to see double images. This prism is put down as the measure of his muscular power. This method is open to many objections, especially in measuring the power of convergence. It is extravagant of time, and is so fatiguing to the patient, that in some susceptible subjects its application is almost impossible. It requires no little intelligent co-operation on the part of the patient; in fact, the knack of overcoming prisms has to be learned by the patient, and, as a rule, when the prism test is made at several successive examinations, we find that the strength of prism overcome increases at each trial, showing that the result is a measure of the patient's power to exercise his muscles in response to our experiments, and not of his total muscular power.

An instrument made by two superposed prisms, so arranged that by rotation the strength of the prism can be gradually increased, offers this advantage over the simple prism, that the patient is more easily induced to exercise up to the limit of his ability, when the strength of the prism employed is so gradually increased that the double images are never suddenly and widely separated. Double images, when standing very near together being more annoying, the effort to fuse them is proportionately greater. But this instrument is clumsy of manipulation, and has the disadvantage of being placed before only one eye, making it more confusing to the patient, but on the whole, I think it is the best instrument for measuring divergence, and if two pairs of such prisms were used, mounted in a frame, and so arranged

as to be rotated simultaneously before each eye, it would be still more satisfactory. But for measuring convergence, it is open to the same objection as all prism tests. It either necessitates making the test at twenty feet, and thus compelling the patient to dissociate convergence and accommodation, which are habitually and normally associated, or, if made at the the near point, so strong a prism is required, that very annoying distortion and chromatic effects are produced.

The ophthalmo-dynamometer of Landolt, which measures convergence by determining how near an object can be brought to the eye without producing diplopia, offers, I think, by far the best method at our command for determining the converging power. But this instrument is not altogether free from objections. The candle is a decided inconvenience, the measurements can only be taken very approximately, and as in taking the measurements, the surgeon is compelled to stand by the patient's side, it is impossible for him to fulfill what seems to me to be one of the chief indications in making the examination,—that is, to watch from in front of the patient the movement of the eyes in convergence; for I think it is frequently the case, that we obtain quite as important information by observing the jerky, halting movements in convergence, as by learning the total converging power.

I have attempted to construct an instrument upon the same general principle as that of Landolt, which will give us a measure of the power of convergence in its physiological harmony with the power of accommodation, and at the same time be both accurate and convenient.

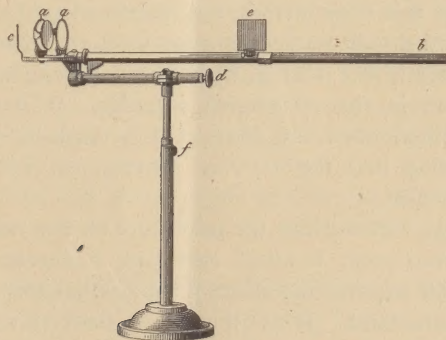


FIG. I.—This instrument is manufactured by Mr. W. E. Gibbs, 111 Liberty St. N. Y.

The instrument consists of a base which supports a brass tube, having at one end a metal block to which are attached lens holders, *a a*. From the block extends a rod upon which the square tube, *b*, slides. At the end of *b*, a yoke extends out on either side of the lens holders, carrying at the extremities upright pins, *c c*. From the lower

side of the tube, *b*, extends an arm, connecting with a screw moved by the milled head, *d*, by the rotation of which the pins can be advanced or withdrawn from the lens-holders. Upon the tube, *b*, slides a carrier supporting the target holder, *e*, which is a triangular box, having upon one side a blackened surface with a highly polished needle placed vertically in the centre; on one of the other two sides are test letters; and on the third side an astigmatic dial. The tube is graduated so that at the front of the carrier you read on one side the distance from the pins to the target in fractions of a metre, *i. e.*, metre angles or dioptries; on the other side, the same distance in inches.

In using the instrument to measure convergence, seat the patient in a comfortable position before it, and adjust it to the required height, fastening it in the desired position by the screw, *f*. Let the patient look through the lens holders, resting against the bridge joining them, and then rotate the head, *d*, till the pins are on a line with the front of the corneæ, which point is sufficiently accurate for all practical purposes, and is much easier of determination than the centre of rotation of the eye. Now advance the target holder, which, at the beginning of the examination should be placed at the extremity of the tube farthest from the patient; direct the patient to look steadily at the needle, and to observe at what point it becomes double. When this point is reached, withdraw the target till the patient is again able to see a single image; that is, to the near point of convergence. Then read at the front of the target the number of metre angles of convergence which the patient possesses.

In making this examination, the surgeon should stand in front of the patient, and should watch the eyes most attentively. If they are seen to converge with a halting, hesitating movement, it shows a lack of proper tone in the converging muscles. It should be further observed, whether, when the near point is reached, one eye quickly diverges, showing that the extreme convergence was reached by a great nervous effort.

It is always well to allow the patient to fix the needle for a short time at the near point, to avoid mistaking a degree of convergence reached by such a spasmodic effort, for the actual converging power at the patient's command. When there is a marked difference in the visual acuity of the two eyes, it is well to place a red glass before the best eye, as it serves to make the patient attentive to the second image.

Should the patient be unable to fuse the two images when the target is at the greatest distance from the patient which the length of the instrument will allow—40 centimetres—place in the lens-holder the two 11° prisms which accompany the instrument, with their bases

toward the nose. These will add 3 m. a. of convergence. Now bring up the target, and determine the near point as before, deducting 3 m. a. from the total convergence.

When the prisms will not unite the images, divergence exists of such a degree that it can be best measured at 20 feet with a candle flame.

If the patient can fuse the images when the target is advanced as near as possible to the eyes, the prisms can again be used, with their bases to the temple, and 3 m. a. added to the convergence.

It is well in any case where muscular insufficiency is suspected, and where it is not shown to exist at the first examination, to repeat the examination at a subsequent visit, to avoid any possible error.

This determination of the punctum proximum of convergence is of the greatest practical importance in arriving at a correct diagnosis in any case of asthenopia or of obscure nervous trouble.

By experience it has been found, that in order to do near work and escape fatigue, a patient must not use more than a quarter or a third of his total converging power. Now when a patient presents himself in whom it is desired to determine whether his symptoms are due to muscular strain, first find at what distance he is in the habit of working; for example, say he is using his eyes for work one-third of a metre distant, and consequently using 3 m. a. of convergence, if upon examination with the dynamometer we find he has less than 9 m. a., we have discovered a sufficient cause for asthenopic symptoms; should we, however, find he has 10 or 12 m. a. of convergence, we know that he can use the 3 m. a. required for his work and still keep three or four times that amount in reserve; we must then seek some other cause for the symptoms. As a general rule, any patient possessing less than 9 m. a. of convergence will suffer from muscular asthenopia.

The instrument is also equally useful in determining the power of accommodation.

We now turn the side of the target upon which the test letters are placed, toward the patient and bring to the nearest point at which they can be clearly seen.

Letters of different sizes are provided, the larger being useful in cases where the visual acuity is low. Having found the nearest point at which the letters can be recognized, the graduations will read as before, only substituting dioptries for m. a. A graduation in inches is also added for the convenience of those using that system.

I find the instrument very convenient in determining the glass required in presbyopia. The total accommodation is easily determined; here we find, according to Landolt, that one-third of the total power is sufficient to leave in reserve, and knowing the distance at

which we wish our patient to work, we at once obtain the glass required by deducting the available accommodation from the glass required to bring his vision to that distance. I do not recommend this or any other method of fitting glasses by rule as alone sufficient; having determined the required glass in this way, the surgeon will of course so modify it as the requirements of the case and his other tests may indicate.

The usefulness of the astigmatic dial is apparent without comment. I find this optometer very convenient in determining whether a patient to be examined is fully under the influence of atropia; and also in determining any deficient power of accommodation which we not infrequently find in over-worked and under-nourished patients.

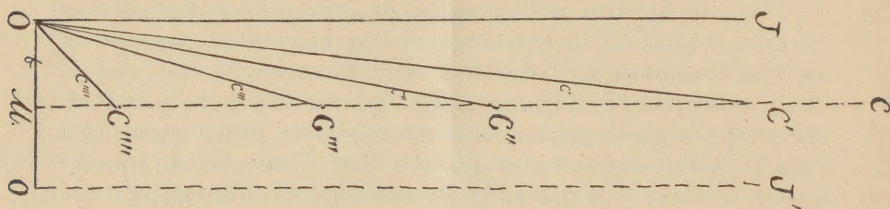


FIG. II.—Cut and explanation from Landolt.

A word of explanation as to the metre angle taken as the unit of measurement may not be amiss. It is the metre angle (metrewinkel) of Nagel, and one metre angle (1 m. a.) the unit, is the angle of convergence necessary to fix simultaneously with both eyes an object situated on the median line at the distance of one metre from the eye. In any given case, the convergence is inversely proportional to the distance between the object fixed and each of the eyes; for example, to fix an object at one-half of a metre would require 2 m. a. of convergence; at one-third of a metre would require 3 m. a., and so on.

By reference to Fig. II. this is easily demonstrated.

Let half the base line, OM , be designated by b , and the distance OC' , from the eye to the object by C' . The angle of convergence is in this case $OC'M$. It is determined by the expression,

$$\sin. OC'M = \frac{b}{C'}$$

or, $b = C' \sin. OC'M$.

We can construct rectangular triangles, $OC'M$, $OC''M$, $OC'''M$, $OC''''M$, whose common base is b ; from these we derive the formulæ.

$b = C' \sin. OC'M = C'' \sin. OC''M = C''' \sin. OC'''M = C'''' \sin. OC''''M$. For the small triangles with which we are dealing, the sine may be regarded as equal to the angle, and equation becomes

$$b = C'. \quad O C' M = C''. \quad O C'' M = C''' \quad O C M \text{ etc.}$$

Letting $b = 1$.

$$\text{Angle } O C' M = \frac{1}{C'}$$

$$\text{Angle } O C'' M = \frac{1}{C''}$$

$$\text{Angle } O C''' M = \frac{1}{C'''}$$

$$\text{Angle } O C'''' M = \frac{1}{C''''}$$

that is, the angles of convergence are inverses of the distances of the object from the eye.

If $C' = 1$ metre, the corresponding convergence is $C = \frac{1}{1} = 1$ m. a.

$$C'' = \frac{1 \text{ m}}{2} \quad \text{“} \quad \text{“} \quad \text{“} \quad C = \frac{1}{\frac{1}{2}} = 2 \text{ m. a.}$$

$$C''' = \frac{1 \text{ m}}{3} \quad \text{“} \quad \text{“} \quad \text{“} \quad C = \frac{1}{\frac{1}{3}} = 3 \text{ m. a.}$$

$$C'''' = \frac{1 \text{ m}}{4} \quad \text{“} \quad \text{“} \quad \text{“} \quad C = \frac{1}{\frac{1}{4}} = 4 \text{ m. a.}$$

The results obtained with prisms in testing divergence may be easily reduced to the same notation, for the deviation produced by a prism is equal to half its angle of opening. A prism X° produces a deviation of $\frac{X^\circ}{2}$ or $\frac{X \times 60'}{2}$; dividing this by $110'$, the value of the metre angle ($1^\circ 50'$) for a base line of 64 mm., the equation becomes $\frac{X \times 60'}{2 \times 110} = \frac{X \times 3}{11}$; when held before only one eye, and its action divided between the two, we have $\frac{3 \times X}{22}$; with a base line of 58 m. we have $\frac{3 \times X}{20}$, the average $\frac{3 \times X}{20} = \frac{X}{7}$. That is, we may obtain approximately in metre angles the deviation produced in each eye when a prism is held before one by dividing the number of the prism by 7.

